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Presented to City Archives. 16 Aug. 1940
by his widow, Mrs M. M. Butwell. (née Black)
1058 Nelson St

THE VANCOUVER WATER SUPPLY

By

H. M. Burwell, C. E.

January 25th, 1913

SEYMOUR CREEK WATER FALL

Capilano and Seymour Creek Supply Systems

The City of Vancouver is supplied with water from two sources, i.e., Capilano and Seymour Creeks. These two mountain streams have drainage areas of about 55 and 80 square miles respectively, and empty into the northerly side of Burrard Inlet at the First and Second Narrows.

The First Narrows are westerly and the Second easterly from the city. Both creeks are rapid running, clear water mountain streams with a fall of about 70 feet to the mile, offering ideal facilities for a dual gravity supply to the city at a comparatively small cost.

Capilano Creek is fed from high timbered mountains from 1,000 to 5,000 feet in height, and, it is estimated, has an average run off of about 310 cubic feet per second.

The discharge has a very wide variation and fluctuates from as high a maximum as 15,000 cubic feet per second (usually in the month of November) to as low as about 10 cubic feet per second in the month of August.

There are no available natural storage reservoirs of extensive area in its valley which can be cheaply developed to equalize the run-off, so that a supply from 40 to 50 cubic feet per second is all that can be economically taken at the present time.

The water is pure mountain water from the melting snow, being greatly conserved by the dense primeval forests of fir, cedar, hemlock, spruce and balsam, which, up to the present time, have not been cut down or interfered with.

With the exception of a few days in each year during the highest freshets, it is quite clear and free from sediment, and does not require to pass through filter beds before entering the intake pipe.

Capilano Intake

The present new intake is located at a point about 7 miles up from the mouth of Capilano Creek at an elevation of 480 feet above the sea level and distant about 10 miles from the central part of Vancouver.

In the year 1906, an intake to the new 36-inch supply main then constructed, was placed at a point known as the "Pool," being distant up-stream about three-quarters of a mile from the original intake at the dam, which has since been abandoned.

This pool is formed by a reef of granite rock extending out into the channel of Capilano Creek from the east side, and has a depth in the centre of about 15 feet at low water.

The intake pipe and racks were placed in the pool just behind this point of rock, clear of the current of Capilano Creek, which at this point is a very rapid-running stream, with a fall of about 80 feet to the mile.

The deflection of the current by the above mentioned point of rock caused an eddy in the pool behind, which had always kept it deep and free from gravel or sediment, and for this reason it was thought at the time to be an ideal location for an intake.

Subsequent experience, however, has proven that the slight alteration which the placing of this intake caused to the natural condition which before existed, had the effect of altering the eddy to such an extent that large quantities of sediment were annually deposited in what was originally deep water in front of the intake, greatly reducing its value for the purposes expected.

After having observed the operation and effect of this intake for four years, it was decided to construct a new intake through the

center of the point of rock above referred to, built in such a manner that the water entering into it would flow in a direction at right angles to the current of the creek.

The advantage of this arrangement is obvious in a stream of this nature, which at freshet times (occurring usually in the month of November), carries down great quantities of boulders, gravel and sediment.

The velocity of the creek's current being very much greater than the velocity of the water entering into the intake, carries most of the sediment past the intake, which would otherwise enter into or pile up in front of it.

The new intake has a width of 10 feet and height of 18 feet, its height being fixed by the highest known flood level that has occurred during the last 25 years.

It is constructed with reinforced concrete side walls and a concrete bottom, the entrance being provided with head racks of oak strips set in angle-iron frames.

There are four in all, each measuring 5 feet by 9 feet, placed in guides formed with an "I" beam in the centre, and channels set in the concrete walls.

These racks extend from the bottom to the top of the intake and can be raked at any stage of the water and removed when desired.

The upper section of the intake conduit, for a length of about 75 feet, was excavated through granite rock. In plan it has a sharp curve at a point about 40 feet from the intake and below this point its width is reduced to 7 feet.

The head gate is placed at a point 175 feet from the intake and below this point the side walls of the conduit are reduced to 10 feet in height by three steps.

The conduit is an open concrete flume, and has a total length of 570 feet from the intake down to the sediment tanks.

t is constructed throughout with side walls 12 inches in thickness, reinforced with ¾-inch round iron, also being provided with beams across from one wall to the other as a reinforcement against pressure of the earth banks.

The bottom of the flume has a thickness of about 12 inches and below the head gate is also reinforced to withstand the upward pressure which is put against it during the high water stages of the creek, owing to the porous nature of the ground.

The head gate is built of channel irons, and has a width of 7 feet and height of 5 feet 10 inches.

It is placed in channel guides set in the concrete walls and is operated by a long stem and spur-gear, which is fastened to the channel frame set on top of the walls.

The gate opening at the bottom of the flume is 5 feet in height and above this is a concrete bulkhead reinforced with steel rails.

There are two gates at the lower end of the flume which admit water into each of the sediment tanks.

These were made by cutting holes 4 feet by 5 feet in the concrete walls of the tanks to which the gate frames and gear are fastened.

The new intake has been in operation for several months and in the month of November was subjected to a very severe test by an extremly heavy freshet in the creek.

It was observed after the water receded, that not more than about one-quarter of the usual sediment was deposited in the tanks, and in every other respect it has proven to be much superior to the old one.

The sediment tanks above referred to are two in number, each with a length of 100 feet, a width of 20 feet, a depth of 9 feet at high water overflow level, and a depth of 6 feet at low water overflow level. They are designed to separate the sand and other heavy sediment from the water before it enters the supply main, and are provided with a double row of screens to catch all suspended or floating matter.

Each tank has a large scour gate, and can be cleaned and flushed out at any time desired, the material being carried away through a 22-inch steel pipe placed below the tanks.

The supply main from the sediment tanks down to the site of the old dam (a distance of three-quarters of a mile), consists of a continuous wooden stave pipe 36 inches in diameter.

At the lower end of this pipe is placed a "Y" pipe and gate valves which connect with a 30-inch continuous wooden stave pipe and a 22-inch steel riveted pipe. The 22-inch steel riveted pipe extends down to the canyon tunnel, a distance of about two and a half miles.

The 30-inch continuous wooden pipe extends down for a distance of about one and a quarter miles, where the static head reaches 190 feet, and from here down to the canyon tunnel is a steel riveted pipe of the same diameter.

At the lower end of this pipe is placed a "Y" pipe connecting with a 22-inch steel pipe in present use, and a 26-inch steel riveted pipe now being constructed (of which mention will be made later on).

The old tunnel at the Canyon was constructed many years ago, when the intake was located at the old dam referred to, and was designed to keep the pipe line at this point below the hydraulic grade.

It was not constructed of a sufficient size to provide for all future requirements, so that it became necessary to excavate another tunnel alongside it to provide for the extensions now being made.

There are two 22-inch steel riveted pipes passing through the old tunnel, which are connected together by means of "T's" and gate valves at a point near the south portal.

From this point there are two steel riveted pipes in use, which extend down to the north shore of the First Narrows of Burrard Inlet, (a distance of about three and three-quarter miles), one 16 inches in diameter, installed in the year 1888, and the other 22 inches in diameter, constructed a few years later.

These two pipes are provided with a cross connection at the lower end and connect with six submerged mains, passing under the Narrows, each 12 inches in diameter and constructed of cast-iron with flexible joints. The length of each line of flexible pipes is about 1,300 feet, but with the shore connections the total distance across the narrows is about half a mile.

These six mains across the Narrows connect on the south side with two steel riveted pipes, which extend through Stanley Park to the city, one of them being 16 inches in diameter and the other 22 inches in diameter, with the exception of a short section across Coal Harbour, where two cast-iron pipes are used, one 18 inches and the other 20 inches in diameter. They connect with the city distribution system at the westerly end of Georgia Street, and are provided with a cross-connection with gate and check valves near the south side of the Narrows.

From the 22-inch main a branch pipe 22 inches in diameter extends to Stanley Park Reservoir. In the connection here is placed a 12-inch relief valve which is used to regulate the maximum pressure in the city distribution, all surplus discharging into the reservoir. This reservoir has a capacity of about 10,000,000 gallons, and was designed to fill the requirements as a distributing reservoir in the early days when the city was built chiefly on the lower levels. It has an elevation of only 240 feet above sea level, and since the city has expanded to the higher levels, it has become necessary to increase the pressure throughout to about 25 pounds above the pressure that could be attained from this reservoir level. It has, practically speaking, been put out of business, except that it has value as a stored reserve, which can be utilized for the lower levels in cases of emergency.

The 26-inch steel riveted supply main above referred to, is now being constructed, and is named the Vancouver-Point Grey Partnership Pipe, the agreement between the City and the Municipality of Point Grey being that the cost of this main shall be borne equally

by each and that an equal division of the water conveyed shall be made at a point agreed upon. This pipe will start from the "Y" pipe at the lower end of the 30-inch pipe referred to and will pass through the new tunnel constructed at the Capilano Canyon. This tunnel has a length of about 600 feet, a height of 6 feet and a width of 7 feet, suitable for the accommodation of two pipes.

The 26-inch main will extend from here down to the First Narrows, a distance of about three and a half miles, and will here connect with two 18-inch cast-iron submerged mains with shore connections, provided with "Y" pipes and two 18-inch check valves at the south shore, also two 18-inch gates at the north shore. From here the 26-inch main will extend through Stanley Park, across Coal Harbour and along a suitable route to the most favourable crossing of False Creek (a 24-inch emergency connection being made with the city distribution system at Georgia Street). From False Creek southerly the 26-inch main will extend along the most suitable streets (to be selected), terminating at Bodwell Road, where the division of water will be made with the Municipality of Point Grey by a branch pipe extending westerly to their reservoir, and another one extending east to the City Reservoir on Little Mountain. The total length of this partnership pipe line will be about ten miles and the estimated cost $330,000.00. The construction is now under way, and it is expected it will be finished by the end of this year.

Seymour Creek

The city, prior to the year 1908, depended entirely on its water supply from Capilano Creek. This supply had been adequate up to that time, but owing to the rapid increase in population, the necessity of securing water from another source of supply was made apparent for the following reasons:—

(1) The extreme low water stage in the Capilano would not be sufficient for the future population.

(2) Owing to the rapid fall of this creek it would be impossible to create storage reservoirs in its narrow valley at a permissable cost.

(3) And finally, the crossing of the supply main under the First Narrows (being the entrance to Vancouver Harbour) made a dangerous point in this water system (several of the submerged pipes having already been broken by ship's keels). The City Council therefore decided to secure an additional supply from Seymour Creek, and completed the installation of this system in the year 1908.

Seymour Creek empties into the northerly side of Burrard Inlet at the Second Narrows, situated near the north-easterly corner of the city. It is a beautiful clear mountain stream (except once or twice annually), and has a fall at the lower part of about 65 to 70 feet per mile. Its drainage area is about 80 square miles and its

mean annual run-off about 500 sec. feet. The low water flow is about 80 cubic feet per second, and the maximum about the same as Capilano. At its source is a lake of from 400 to 500 acres, at an elevation of about 3,000 feet above sea level. In this neighbourhood there are also snow-fields which help to maintain the supply of water during the summer months.

The present water works intake in use is located seven miles up from the mouth of the stream, being distant about 11 miles from the central part of Vancouver, and has an elevation of 465 feet above sea level. Owing to the large amount of boulders, gravel and finer sediment which the creek carries down at freshet times, it was necessary to design the intake so that it would not become completely choked up at such times, and means had also to be provided to prevent the finer sediment entering the pipe.

The intake is formed by a hewn cedar crib with rock filling, made 13 feet in height. There are two openings, each 5 feet in width, and on the face of each opening there is placed an oak rack, set in an iron frame. The water enters the intake at right angles to the direction of the stream, the faces of the racks being parallel with the stream. This allows boulders and most of the heavy sediment carried down by freshets to be swept away, as the current of the stream is stronger than that of the water entering the intake.

About 50 feet below the intake a low boulder weir extends across the creek. This is composed of large broken rocks containing about half a cubic yard each, which were hauled in place by a donkey engine. This weir has only a sufficient height to keep a sufficient depth of water on the intake during the extreme low water period.

The water passing through the racks enters an 11 by 14 foot forebay. From here there is an open conduit 6 feet in width, of hewn cedar crib-work. This conduit extends down stream along the bank of the creek for a distance of 300 feet. Its upper end is furnished with a 6 by 10 foot head gate. At the lower end of the open conduit is placed a scour gate discharging into the creek, its duty being to flush out the sediment which may enter the intake and deposit itself along the flume.

Just below here are located two sediment tanks designed to separate the finer sediment and floating matter from the water and prevent it from entering the pipe. These tanks are built of 6 by 12 in. sawn timbers, the sticks all being placed flatwise and drift-bolted together with frequent tie-sticks extending into the bank.

Each tank is 20 by 100 feet in plan, by 6 feet deep, and is lined with 3 inches of concrete fastened on the sides with expanded metal spiked to the timber walls.

The floors of the tanks were made by first covering the ground (which consists of a compact mass of boulders and gravel) with

expanded metal. This was fastened with numerous ¾-inch anchor bolts driven down in between the boulders, after which 3 inches of concrete was floated through and over the whole. The object of the anchor bolts was to withstand the upward pressure which occurs at extreme high water in the creek.

Each tank is supplied with a 4 by 5 foot inlet gate and one of the same dimensions at the lower end which admits the water to the supply main leading to the city.

A few feet in front of the lower gates are placed two rows of screens extending across the entire width of both tanks. There are 16 screens in all, each 5 feet square. They have iron frames backed with heavy steel netting and are fitted in front with light wooden frames in which the fine screens are fastened. The screens are operated by a hydraulic hoist, which lifts a row of eight at a time, when the whole row is cleaned by means of a strong jet of water. The refuse falls into a cement trough in the floor and is carried out into the creek. The water for this work is supplied from a small mountain creek, through a 4-inch pipe under a 125-foot head.

Across the bottom of both tanks is placed a baffle 18 inches in height, situated about 6 feet in front of the screens. Its duty is to prevent the sunken matter and heavier sediment from coming in contact with the screens.

Just above the baffle is built a skimmer which crosses both tanks. This contrivance takes care of the overflow and carries off all floating matter. Each tank is provided with a scour gate 24 inches square, placed on its floor by means of which a tank can be flushed out without interfering with the supply to the city.

The Supply Main

Before constructing the supply main, a good wagon road was built along the location of the pipe line. It has a maximum grade of 4½ per cent., and a total length of seven miles. For the first 3¾ miles below the intake, it is located on the westerly side of Seymour Creek. It then crosses the creek on a steel bridge, and extends along the easterly side of the Second Narrows of Burrard Inlet. About half a mile below the bridge, the Seymour Creek Canyon is encountered, where the creek passes through a deep cleft in the rock, having almost perpendicular walls on each side. Here the road is excavated through rock along the edge of the canyon for some distance and is very picturesque.

Wood Stave Pipe

The pipe is built along the side of the road farthest away from the creek. For the first 1,000 feet it consists of a continuous wood stave pipe, 36 inches in diameter. From here down to the canyon, (where there is a slight summit in profile), it consists of a continu-

ous wood stave pipe 30 inches inside diameter. The total length of wood pipe is 4 1/3 miles. The staves of which the pipe is built have a thickness to 2 inches, and were chiefly cut from fir timber, although some cedar was used. They were manufactured near the site of the work, as well as the lumber used in the sediment tanks and intake buildings. The city purchased a portable saw mill and logging donkey engine for this purpose.

The price of the class of lumber required would have been $40 per 1,000 feet (board measure), at the mills in Vancouver. Haulage and handling it at least three times would have brought it up to not less than $50 per 1,000 feet on the line. The actual cost of the lumber used in the pipe, including the cost of the saw mill, was $28.50 per 1,000 feet, making a considerable saving in this respect.

The wood pipe is supplied with two 30-inch gate valves, one placed about one and a half miles below the intake, and the other about three miles below. They were placed in those positions, partly for use in case of emergency, and partly to facilitate the construction of the pipe. The pipe in one place will be subjected to a pressure to a static head of 210 feet, and this part (which is near the bridge) has the steel bands spaced 1¾ inches c to c.

The bands are ½-inch in diameter, fitted with forged steel shoes, and have an average spacing of 3¾ inches c to c.

Bridge Crossing

The crossing of the bridge is made with a 32-inch continuous steel riveted pipe, with bends and special connections for wooden pipe at both ends. It is furnished with a 6-inch blow-off at the centre and rests upon floor beams of the bridge. The water-tight connections between this steel pipe and the wooden pipes are made with ordinary lead joints. Where the pipe line crosses ravines or small hill-side creeks, it is supported on substantial cedar trestles, and is enclosed in cedar crib work filled in with sand and gravel.

In two places where it is thought there might be danger from fires, the pipe line is supplied with 2-inch valves, with a length of hose and a nozzle in each place enclosed in a small house.

Welded Steel Pipe

From the canyon down to the Second Narrows, the pipe line is constructed with 24-inch lap-welded pipe. The shell of the pipe has a thickness of 5/16 inch, and is made in about 19 foot lengths, and known as "Stewart's Patent Inserted Joint," lap-welded steel pipe, and cost $3.80 per foot delivered at Vancouver.

At the supper end it is supplied with a 24-inch gate valve and a 6-inch blow-off. At the Narrows it connects with two 18-inch submerged mains by means of a "Y" special, and shore connec-

tions. It is here supplied with a 6-inch blow-off, placed within a concrete well, which encloses the "Y" and two 18 inch gate valves. The ground here being covered with tidal water at times of high tide.

Submerged Mains

The total distance across the Second Narrows is 2,600 feet, but only 1,000 feet of the channel is deep water, the rest being tidal flats uncovered at low water.

The channel has a depth in the central portion of 75 feet at low water. In this portion there are used two 18-inch flexible cast-iron pipes, built in lengths of 9 feet, with a 1½-inch shell. Each pipe length weighs from 3,300 to 3,600 lbs., and each joint is capable of a total deflection of 19°. The pipe is of the ball and socket type. The ball is formed by running lead into the joint after the pipe has been placed together. The shore connections, amounting to 1,600 feet, are made partly of steel and partly of ordinary cast-iron pipes.

The most interesting feature in connection with the submerged mains, was the placing of the flexible pipes along the bottom of the deep channel. This was accomplished by first building a wooden trough or chute on the tidal flat on the northerly shore, directly in line with the crossing, and extending out to the edge of the deep channel. The chute was made of 3 x 12-inch lumber, supported on trestles, and of a length equal to that of the flexible main. It was well greased on the inside, after which the pipes were placed in and joined together, the bell-ends each resting on a short board forming a sort of sled used to keep the pipes in place and to reduce the friction in sliding them along.

A 1½-inch steel cable was then drawn through the pipe and fastened on to eye-bolts at each end, made of 2-inch Norway iron, and about 8 feet in length. These passed through cast-iron caps placed at each end of the pipe. The rear bolt was threaded for about 6 feet, and provided with a large nut by which the cable inside of the pipe was made taut. The front end cap was provided with a stuffing-box to permit the movement of the eye-bolt outward as the strain came on the inside cable, without taking water into the pipe. Three 1½-inch steel hauling cables were then fastened to the pipe. One was fastened to the pipe about one-third the distance back from the front end, one at the front end, and the other was fastened to the above eye-bolt.

As the Canadian Pacific Railway passes along the southerly shore of the Narrows, close to the water's edge, a bridge had to be erected over the track to prevent intereference with traffic. The cables were carried over on top of this bridge, which was built on a slope of about 17 degrees, owing to the high bank to the south of the track. The platform was extended up-hill to a large spruce stump, which was used in addition to a log dead-man anchor for

hauling the pipe. At the lower end of the platform, which was 85 feet in length, was placed a wooden roller, over which the hauling cables passed. The hauling was performed by means of five capstans operated with horses. These were capable, with the blocks and tackle used, of putting a strain of about 180 tons on the hauling cables.

In hauling the several 12-inch mains across the First Narrows, in the Capilano system, it was noticed by the time the ends of the mains were landed on the south shore, the pipes were always full of water, caused by leaks at the numerous joints. This would add about 51 tons to the weight of the pipe when all submerged, and make the hauling more difficult, especially as the last part of the haul was up a steep incline. The new main being much heavier than the prior ones hauled, it was decided to take no chances in this respect. Accordingly an air compressor was used and kept a continual pressure of from 50 to 60 lbs. in the pipe to keep out the water during the whole time that it was being hauled.

The haulage was done by day labour and was accomplished without experiencing any unusual difficulty, although the pipe was much heavier than any hauled previously, and the slopes of the channel steeper and rougher than at the First Narrows.

The conduit from the Second Narrows to the city, where it connects with the distribution system (a distance of about three miles), is a 24-inch lap-welded steel pipe, with the exception noted below. The connection with the submerged pipe here is made by means of a "Y," the same as on the north shore, but in addition to the two 18-inch gate valves there are two 18-inch check valves bolted to the gate valves. The pipe here passes under the railway tracks in a concrete lined tunnel, in which is placed a special steel riveted pipe, with the necessary "T" and bends, all riveted together and resting in concrete saddles and concrete backings at the bends.

The pipe line, after passing through the tunnel, follows along the railway right-of-way for a distance of about half a mile (owing to the precipitous nature of the ground adjoining the railway). In accordance with an agreement with the Railway Company, this portion is made of 3/8-inch steel plates. After leaving the right-of-way the pipe line follows along a course through Hastings Park to Eton Street, along this street to Powell, and along Powell Street, terminating at McLean Drive.

The total length of the supply main from the intake to where it connects with the distribution system in the city, is about 10½ miles, and the capacity of the system is about 9,000,000 gallons per day, or about equal to that of the present Capilano system.

Cost Data

The wagon road along Seymour Creek was built by contract at a cost of $11,500. The work contained some very heavy side-hill cuttings and a considerable quantity of rock work.

The pipe trench for most of its length was excavated through a compact mass of large boulders and gravel, deposited by glacial action. That portion along the edge of the canyon was excavated through granite rock.

The trench for the wooden pipe 4 feet in depth by 5 feet in width was performed by contract, the price being 49 cents per lineal foot. The rock work being paid for per cubic yard brought the average cost of this trench up to 73 cents per lineal foot.

Cost of Wood Stave Pipe

	Per Lin. Ft.
Excavation of trench (contract)	$ .73
Building pipe	.39
Steel bands, including haulage	1.38
Lumber, including haulage	.65
Tongues, including haulage	.02
Paint for bands, including haulage	.02
Inspection	.01
Back filling over pipe (day labour)	.25
Total	$ 3.45

Cost of Steel Pipe

Excavating trench (day labour)	$ .85
Steel Pipe	3.80
Laying and making joints, including lead	.23
Back filling	.25
Haulage of steel pipes (day labour)	.07
Total	$ 5.20

SUMMARY OF THE COST OF THE WHOLE WORK PERFORMED

NORTH SIDE OF BURRARD INLET

Wagon road (contract)	$11,500
Wharf and approach at Narrows (contract)	6,000
Steel bridge	7,000
Warehouse and camp buildings	1,500
Intake and sediment tanks, including lumber, screens, gates, complete (day labour)	19,500
Wooden stave pipe line (contract)	78,500
Steel pipe line (day labour) trench and laying	76,500
Gate valves, special steel pipe, bends, air-valves, etc.	3,500
Trestles and culverts (day labour)	3,500
Repair work to road, cutting out slides and corduroy work (day labour)	3,500
Protection work to pipe line, riprap and crib work (day labour)	6,000

Telephone line	1,000
Portable saw mill	6,000
Logging donkey engine	3,000
Rough lumber in stock	9,000
Teaming	1,000
Total	$270,000

SUBMERGED MAIN (One main only)

Flexible c. I. pipe, 1,000 ft.	$ 8,500
Hauling flexible pipe (day labour)	1,000
1,600 feet steel and c. I. pipe (shore connections)	7,500
Laying pipe and making shore connections, including delivery from city of all pipes	4,000
Gate valves and specials	2,500
Lumber and tools	500
Protection work, rip rap and concreting	1,000
Lead	2,000
Total	$27,000

SOUTH SIDE OF BURRARD INLET

Tunnel under railway track, concrete lined, with [illegible]0 ft. shaft	$ 2,500
Special steel riveted pipe with concrete saddles and anchoring	2,000
Steel main to city connecting with Capilano system complete	86,500
Total	$91,000
This brings the cost of the old Seymour Creek system up to	$388,000
For engineering and superintendence	11,000
Total	$399,000

This amount does not include the cost of the land purchased for reservoir sites, foreshore land, pipe line right-of-ways and legal expenses. The cost of the ordinary labour at the time of construction varied from $2.80 to $3.00 per day of 10 hours, regulated by the City Council.

NOTE:—The second submerged main was installed since the foregoing was written.

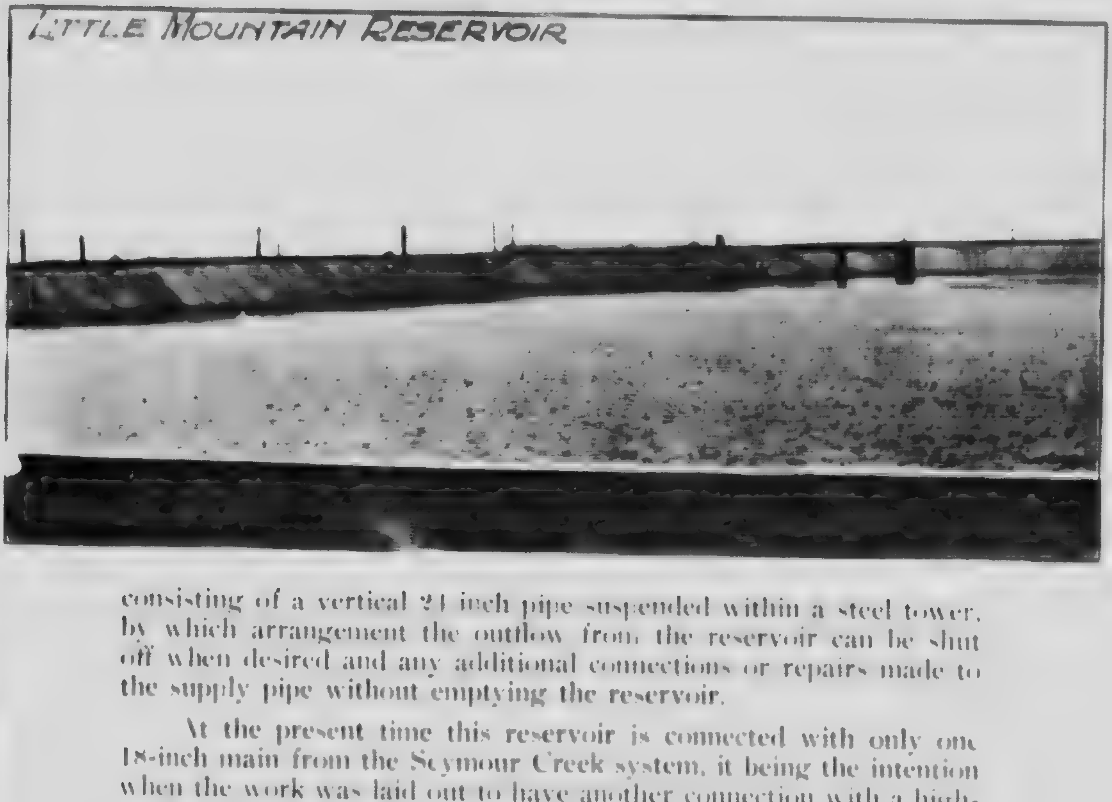
LITTLE MOUNTAIN RESERVOIR

This reservoir is located at a point known as Little Mountain, distant about one mile southerly from the city, with a top elevation of 400 feet above sea level. It was completed in the year 1911, and has a capacity of 25,000,000 Imperial gallons, or 30,000,000 U. S. gallons when filled up to the normal overflow level of the waste pipe, and 30,000,000 Imperial gallons filled up to the top (elevation 400 feet). It is an equalizing reservoir designed to take care of fluctuations which occur in the city's demand.

It provides for extraordinary requirements such as would be necessary in the event of several large fires occurring at one time throughout different parts of the city. When the demand for water would for several hours' time probably be in excess of the capacity of the supply mains, the reservoir would then provide for this deficiency and maintain the necessary supply during this time of exceptional draft.

In addition to the above duty, it will contain a sufficient storage to maintain the supply to the present population for about three days' time, in the event of an interruption in one of the supply mains from either the Capilano or Seymour Creek.

The one 24-inch pipe into this reservoir acts both as inlet and outlet, and is provided with a balanced valve inside of the reservoir,



consisting of a vertical 24 inch pipe suspended within a steel tower, by which arrangement the outflow from the reservoir can be shut off when desired and any additional connections or repairs made to the supply pipe without emptying the reservoir.

At the present time this reservoir is connected with only one 18-inch main from the Seymour Creek system, it being the intention when the work was laid out to have another connection with a high-pressure pipe from the Capilano system, so that in the event of an interruption in one of these pipes the other would maintain the supply.

The Capilano connection is now being constructed, and known as the "Partnership Pipe," of which a description has already been given. In addition to the above two connections, still another con-

nection with Seymour Creek is now being made, a description of which will follow. The following are the dimensions of the reservoir, its capacity and other information:

Top length of reservoir	642 feet
Bottom length of reservoir	544 "
Top width of reservoir	377 "
Bottom width of reservoir	280 "
Depth from top to bottom	25 "
Slopes of inside	2 horizontal to 1 vertical
Top width of bank	45 feet
Width of base of bank	145 "
Total excavation	80,000 cubic yards
Rock excavation	18,000 " "
Plain concrete lining	15,030 " "
Reinforced concrete lining	9,835 " "
Cost of excavation	$52,000
Cost of concrete lining	43,000
Total cost	$95,000

Capacity when filled to the top.........30,000,000 Imperial gallons
Capacity with a depth of 22 feet to the top..25,000,000 Imperial Gal.
Elevation of top above sea level........................ 400 feet

GENERAL DESCRIPTION OF WORK

The excavation work was performed under contract and consisted chiefly of a very hard compact mass of boulder-clay containing large stones overlying bed-rock, all of which had to be drilled and blasted before it could be removed with the steam shovel. The material excavated was filled into dump carts, then hauled away from the shovel by dinkey locomotives and placed in the banks.

The banks are formed throughout (except at the rock cut) with the material excavated from the site of the reservoir, the inside portion of the banks being made with the finer and most suitable material for this purpose, and the outer portion formed from the coarser material, boulders and excavated rock.

The finished outside slope of the bank for its entire length is formed with the large pieces of broken rock excavated from bed-rock. This adds to the stability of the bank, improves its appearance and prevents erosion from the heavy winter rains.

LINING OF RESERVOIR

The lining of the bottom consists of concrete slabs made in 12 foot squares, 4½ inches in thickness and provided with parting joints. The side slopes are lined with reinforced concrete, with an

average thickness of $1\frac{1}{2}$ inches. The reinforcement is made with Clinton electrically welded wire cloth, Nos. 6, 8 and 10 gauge, the mixture throughout consisting of one part Portland cement, two parts washed sand and 4 parts broken rock.

This lining was made in sections 12 feet wide, which were started at the bottom and carried up to the coping at the top of the bank in one continuous operation.

Between each section a parting joint has been formed and designed to provide for contraction or expansion in the lining and at the same time maintain a water-tight joint.

INLET PIPE

The inlet pipe consists of a continuous steel riveted pipe with a diameter of 24 inches, built of $\frac{3}{8}$-inch steel plate. This pipe was placed in an excavated trench and embedded in concrete before the reservoir was started, and passes through two concrete bulkheads or cut-off walls. The total cost of the actual reservoir work was $95,000.00, which brings the cost per 1,000 Imperial gallons capacity at $3.80.

The valve arrangement already installed just outside of the reservoir embankment, consists of an 18-inch swing check and an 18-inch automatic regulating valve, also an 18-inch scour valve, all enclosed within a concrete valve house.

The future additions proposed here would be a 24-inch connection from the new high level Seymour Creek supply main, and an 18-inch connection from the Capilano system, made through a 24-inch regulating valve.

NEW HIGH LEVEL SEYMOUR CREEK SUPPLY MAIN

It is expected that this new main will be finished and in operation before the end of next May, (1913), the following being a description of the work:

This supply main from the Second Narrows up to its temporary intake, has a diameter of 36 inches, the diameter here being fixed by an agreement with the Municipality of Burnaby, who will receive water through an 18-inch connection at the north side of the Narrows.

The contract was let to the Macdonald, Godson Co., Ltd., of this city on May 31st, 1911, for supplying 40,000 feet of steel riveted pipe 36 inches in diameter; 20,000 feet of steel riveted pipe 32 inches in diameter, and 6,500 feet of lap-welded pipe 18 inches in diameter. The 36-inch pipe is built of plate ranging from 5/16-inch in thickness to 7/16-inch, costing $4.00 and $4.96 per foot, a short section at the upper end being built of $\frac{1}{4}$-inch plate.

The 32-inch pipe is built of 5/16-inch plate and the price paid for this pipe is $3.58 per foot all delivered at Vancouver, duty, freight and all other charges paid.

The contract was also let on the same date to Balfour, Guthrie & Co., of this city, for supplying 4,000 feet of 18-inch cast-iron flexible pipes at $35.00 per ton.

On December 30th, 1911, the contract was let to Balfour, Guthrie & Co., for supplying 24,000 feet of 24-inch lap-welded steel pipes built of 1/4-inch and 5/16-inch plate at $2.67 and $3.15 per foot, and A. J. Forsyth & Co., of this city secured the contract for supplying all gate valves for this new main at a total of $8,687.00, (manufactured by Glenfield & Kennedy, Ltd., Scotland).

The trench for the 36-inch main was given to the Burrard Engineering Co., of the city, at $1.04 per lineal foot, which includes the bell holes (up to a specified number) and back filling.

The 36-inch pipe referred to is a continuous steel riveted pipe extending alongside the present Seymour Creek supply main from the Second Narrows of Burrard Inlet to the temporary intake located about 2,000 feet up-stream from the present one.

It is designed with a sufficient strength to withstand the extra pressure it will be subjected to when the permanent intake at the water fall on Seymour Creek is finally installed (about 65 lbs. above the present pressure and is provided with three 36-inch gate valves for use in cases of emergency, one at the intake, one two miles below and one at a point 2 3/4 miles from the Second Narrows.

The new pipe crosses on the old steel bridge over Seymour Creek, being supported across this span of 105 feet with reinforcing truss rods, so that most of its weight comes directly onto the concrete piers at each side.

At the canyon, a short distance below here, owing to the narrowness of the original rock-cut along the side of this bluff and the danger in which the old pipe would have been placed by the necessary blasting operations carried on by widening the cut, it was thought advisable to tunnel through this point of rock.

This tunnel has a length of about 700 feet and was built sufficiently large (8 feet wide) to accommodate another large supply main when this future extension is required.

The temporary intake referred to has an elevation of 490 feet above sea level and is a wooden structure similar in general arrangement to the one in present use, being designed to suit the peculiar conditions which exist on this stream. There is no diverting dam and the water enters the intake at the side of the creek at right angles to the direction of the current. Years of experience on these mountain streams has proven this arrangement to be the only satisfactory one so far discovered. The sediment tanks below the intake are designed to separate the sediment which enters the intake during floods.

These streams carry down large quantities of sand and silt during about four or five days in each year (usually in the month of November), but for the rest of the year they are beautiful clear

water creeks. The arrangement of the valves and "Y" pipes below the tanks make provision for the future 18-inch pipe line extension up to the permanent intake at the waterfall mentioned above.

At the north shore of the Second Narrows there are placed three cast-iron "Y" pipes with 18-inch gate valves by which the 36-inch steel pipe is connected with the four 18-inch shore connections of the flexible cast-iron submerged mains which here cross the Second Narrows.

SUBMERGED MAINS

The new submerged mains are four in number, and are located along a line about 400 feet easterly from the old location. They are 18 inches in diameter and similar in all other respects to the two old ones installed.

The method of hauling these across the Narrows was somewhat similar to that adopted in hauling the old ones, except that a large logging donkey engine was employed instead of the capstans and horses used formerly, the arrangement of the hauling tackle being altered so that the actual hauling of a single line of pipes could be accomplished in a few hours instead of several days as formerly. Also an additional deadman was placed on the beach, which took half the strain.

Each line of flexible pipes has a length of 1,000 feet, and with the shore connections which are constructed of 18-inch lap-welded steel pipes built of 3/8-inch plate, give a total length across the Narrows of half a mile. The pipes were hauled across in parallel lines 10 feet apart, the easterly pipe being that one which will be used by the Municipality of Burnaby of which mention has been made.

At the south shore of the Narrows the crossing under the Canadian Pacific Railway is made by two small timbered tunnels in each of which are placed two 18-inch lap-welded steel pipes, it being the intention after the water has been turned on to fill up the space around the pipes with concrete.

After crossing under the C. P. R. tracks the four 18-inch pipes extend south about 80 feet where a large cast-iron "Y" pipe is placed to make the connection with the 32-inch continuous steel riveted pipe which extends into the city.

There are placed here four 18-inch gate valves and four 18-inch reflux valves and in addition an emergency connection with an 18-inch valve for the Municipality of Burnaby.

SUPPLY MAIN TO CITY

The 32-inch steel riveted supply main to the city extends south from this point to East Street, thence west along this street to Boundary Road, thence south to Cambridge Street, thence west

to Cassiar Street, thence south to Charles Street, thence west to Clark Drive, a distance of about 3 8/10 miles.

Two gate valves are placed in this pipe line for use in cases of emergency, one near the westerly end, and one about half-way between this point and the Narrows.

At the westerly end of this main, at the corner of Charles Street and Clark Drive there is placed a large cast-iron "Y" pipe which connects with a 24-inch lap-welded steel pipe extending to Little Mountain reservoir and another 24-inch steel pipe extending to the city distribution system. This latter connection is made through a 24-inch gate valve, and a 24-inch pressure reducing valve, manufactured by the Golden-Anderson Valve Specialty Co.

The pipe line making this connection extends north along Clark Drive to Pender Street where a "T" and gate valve are placed, making the connection with the 24-inch distribution pipe installed on this street. From this point, it continues north to Albert, thence east along his street to McLean Drive, thence north along this street to Powell Street where a connection with the old 24-inch Seymour Creek supply main is made.

The 24-inch pipe line extending to Little Mountain reservoir follows south along Clark Drive to 25th Avenue, thence west to Bridge Street, thence south along this street to Bodwell Road, thence east a short distance to the reservoir, the connection being made by a 24-inch regulating valve and a connection with the old 24-inch pipe from the reservoir, and another connection with the old 18-inch pipe in the present valve house. Provision also is made for a connection with the new supply main from Capilano Creek.

FUTURE EXTENSIONS NECESSARY FOR THE SUPPLY OF GREATER VANCOUVER

As a result of the writer's report, the Council of 1910 made an examination of the waterfall on Seymour Creek, and shortly after purchased the land abutting on the west bank of the creek at this point, and also secured a record from the Provincial Government for a storage license of 100 cubic feet per second. This creek is here supplied from high timbered mountains from 5,000 to 6,000 feet in height.

The waterfall is situated four miles above the present intake in use, and offers ideal facilities for the creation of a storage reservoir in the Seymour Creek Valley, and the most suitable intake for all the higher levels of the future Greater Vancouver and adjoining municipalities.

The waterfall is formed by a reef of granite rock which crosses the creek channel, the crest of which is 632 feet above sea level.

By the construction of a concrete dam on top of this rock with a maximum height of 45 feet, there will be flooded an area of 184

acres which it is estimated will give sufficient storage (with the natural flow of the creek during dry periods in summer or winter) to maintain a supply of about 185 cubic feet per second, or an amount sufficient to cover all of the water records granted by the Government on this creek.

In addition to its value as a storage reservoir, this large flooded area will form a settling basin that will greatly improve the water during the heavy freshets which occur once or twice each year, (extending over a period of three or four days), when the water becomes turbid, and in addition to this will also overcome the winter trouble which sometimes exists, owing to the accumulation of anchor ice and snow at the intakes.

The surveyed pipe line from the old intake up to the waterfall, a distance of four miles, extends along the westerly side of the creek and with the exception of about 500 feet of sliding bank, offers no difficulties in construction.

The difficulty of the bank referred to can be overcome by either tunnelling under or cribbing around it.

The survey of the contour line around the flooded area above the proposed dam at the waterfall, was run at an elevation of 677 feet above sea level, and extends up-stream from the falls for a distance of about 4 miles.

All of the necessary land and right-of-way plans have been prepared, so that the city is now in a position to go ahead and acquire all the necessary land for this very important extension to our water works system.

HASTINGS RESERVOIR

The City Council a few years ago purchased ten acres of ground, known as the Hastings Reservoir Site. This land lies at an elevation of 340 feet above sea level, and is distant about one-third of a mile south of the Second Narrows, and one-eighth of a mile east of the east boundary of the city.

The site is an ideal one for the construction of a distributing reservoir for the business sections of the city, and it is proposed to construct a 20,000,000 gallon reservoir here when the expansion of the city demands that this work shall be gone ahead with.

It will be connected with the old Seymour Creek supply main, by extending a 30-inch pipe from the crossing at the Second Narrows, a distance of only about 1,800 feet, provision being made in the construction of the old main for this connection.

It is proposed to regulate the pressure throughout the business sections and lower residential levels from this reservoir which should maintain a pressure about ten pounds above the present average at the Water Works shops.

Daily capacities of different supply pipes under ordinary working conditions *where a pressure of 100 lbs. is maintained at the Water Works shops.*

Old Capilano system	9,000,000	Imperial Gallons
Old Seymour main	9,000,000	" "
New 26-inch Capilano main	4,500,000	" "
New 36-inch Seymour main	13,500,000	" "
Total	36,000,000	Imperial Gallons

The Municipality of Burnaby will receive 3,800,000 gallons and Point Grey 2,200,000 gallons, or a total of 6,000,000, which leaves 30,000,000 gallons for city requirements.

WATER RECORDS

The following isa list of water records owned and controlled by the city:

Capilano Creek	—1500 miners' inches or	42	cubic feet per second
Seymour Creek	—1400 " " "	39	" " " "
" "	— 250 " " "	7	" " " "
" "	— 150 " " "	4	" " " "
" "	—Storage License	100	" " " "
	Total	192	cubic feet per second

AVAILABLE SUPPLY

It will be seen from the foregoing, that the total available supply at the present time considered is 192 cubic feet per second, an amount equivalent to about 104,000,000 Imperial gallons per day, sufficient to supply over 1,000,000 inhabitants at 100 gallons per head per day.

When the time arrives to take into consideration the increasing of this supply it will probably be ascertained that up to a certain limit the most economical development can be made by the utilization of the lakes lying in the Seymour Creek watershed above the waterfall.

MILEAGE OF SUPPLY MAINS

CAPILANO SYSTEM—NORTH SIDE BURRARD INLET

36-in. continuous wood stave pipe	0.75	Miles
30-in. continuous wood stave pipe	1.75	"
30-in. steel riveted pipe	0.75	"
22-in. " " "	6.25	"
16-in. " " "	3.75	"
26-in. " " " (under construction)	3.75	"

First Narrows

12-in. flexible cast-iron pipes	1.45 Miles
12-in. shore connections (cast-iron)	1.35 "
18-in. flexible cast-iron pipes (under construction)	0.70 "
18-in. shore connections (under construction)	0.30 "

South Side of Narrows

22-in. steel riveted pipe into city	3.75 Miles
16-in. " " " " "	3.00 "
26-in. " " " " " to Little Mt. Reservoir, (under construction)	6.00 "

SEYMOUR SYSTEM

NORTH SIDE BURRARD INLET

36-in. continuous wood stave pipe	0.20 Miles
30-in. continuous wood stave pipe	1.15 "
24-in. lap-welded steel pipe	2.75 "
36-in. continuous steel riveted (under construction)	7.50 "

Second Narrows

18-in. flexible cast-iron pipes	0.40 Miles
18-in. shore connections	0.60 "
18-in.. flexible cast-iron pipe (under construction)	0.80 "
18-in. shore connections (under construction)	3.20 "

South Side Second Narrows

24-in. lap-welded steel pipe	2.65 "
16 and 18-in. lap-welded steel pipe	5.90 "
24-in. lap-weldde pipe (under construction)	4.55 "
32-in. continuous steel riveted (under construction)	3.80 "
Total length of all supply mains	71.40 Miles

DISTRIBUTION SYSTEM

The general arrangement of the system is a network of pipes connected together, so that the smaller cross-mains are fed from both ends, forming a gridiron system.

There are in present use about 285 miles of distribution mains ranging from 12 inches down to 4 inches in diameter.

The original pipes installed were made of cast-iron with the exception of a short section of wooden pipe.

Since the year 1906 owing chiefly to the very large percentage of breakage in shipment of cast-iron pipes all pipes purchased (with the exception of a few small c. i. pipes) have been lap-welded steel pipes, made of steel plate sufficiently thick to stand tapping for service connections without the use of special sleeves or bands.

There are up to date 26,000 services installed, 1,450 hydrants and 1,600 meters, the meters being used only where the supply is given to manufacturers or other large consumers.

COST OF WATER WORKS SYSTEM

1891—Original purchase of Capilano system..........	$440,000.00
1892—Completion of system..........................	60,000.00
	$500,000.00
1891-1912—City extensions and reservoirs..........	$2,032,857.82
[redacted]........................	[redacted]
1906-1912—Capilano extensions..................	165,641.09
1906-1912—Seymour Creek Extensions..........	1,063,921.30
1906-1912—Submerged Mains..................	138,571.00
Total Cost to end of 1912..........................	$3,900,991.21

Estimate of work in 1913 on city extensions, Seymour and Capilano extensions—

[redacted]............................	$ 800,000.00
Estimated cost to end of 1913....................	$4,700,991.21

LIFE OF STEEL PIPES

A portion of the original 16-inch steel riveted supply main from Capilano Creek was recently uncovered on Georgia Street, where it had been in use for about 22 years. Upon making a careful examination of this pipe it was found to be in a good state of preservation. The only pitting observed was at a few of the field connections, where the paint had been scraped off in order to make the lead joints and through careless workmanship had never been repainted.

Judging from its present state of preservation this pipe will probably last as long again, so that its total life should not be under 45 years. It has a shell of only ⅛-inch in thickness, coated with an asphaltum compound by dipping the pipe into a bath raised to a temperature of from 300 to 350 degrees Fahrenheit.

Since the year 1905, the minimum thickness adopted for the shell of steel pipes used in the system is 3/16-inch. With good coating and proper care in laying the pipes, they should last for 50 years, under the conditions which exist in Vancouver.

LIFE OF CONTINUOUS WOODEN STAVE PIPE

When the conditions are such as exist in our supply mains, where the pipe throughout its entire length is constantly full of water under pressure, the wood is kept saturated, and if the timber used is carefully selected sound fir, free from sap-wood, the life of the pipe will be fixed by that of the steel bands.

These bands have a diameter of not less than half an inch, and if properly coated with paint, should last as long as the steel pipe.

LIFE OF SUBMERGED MAINS

The life of a flexible cast-iron submerged main under the Narrows of Burrard Inlet, has proven to be about 15 years at the First Narrows, owing to the corrosive action of the salt water and the cutting effect of the sand and gravel wash at the mouth of Capilano Creek, carried backward and forward over the pipes by the swift current of the Narrows.

As the conditions at the Second Narrows are slightly different there is not sufficient data to form an opinion as to the life of the pipes here.

GENERAL

In designing pipe lines a factor of safety of four has been adopted for the strength of pipes against static pressure in the supply mains, but in some cases this strength has been exceeded, where the question of durability and other considerations form important factors.

The nature of the soil in which the pipes are embedded, along both Capilano and Seymour Creeks, is chiefly glacial clay, sand, gravel and boulders. Throughout the city it is somewhat similar, except in a few places soft sandstone and hardpan beds are encountered.

Dredging operations have been started at the First Narrows of Burrard Inlet to widen out this channel to improve navigation. It is proposed to widen the channel along the northerly side for a width of about 800 feet, with a depth over the dredged area of 30 feet at low water. The two new 18-inch submerged mains will be placed about 300 feet easterly from the last main hauled, and will cross the newly dredged bottom. After these pipes have been put into use, the six old pipes will then be removed as dredging operations are carried forward over this other section. The renewal of these pipes will be gone ahead with as soon as the dredging is finished, but instead of using 12-inch pipes as formerly it is proposed to use pipes with a diameter of 18 inches.

Th supply main along Capilano Creek, with the exception of a short section at each end and a section adjoining the canyon tunnel are laid along a public high-way, through the Municipality of North Vancouver.

The Seymour Creek supply system from the intake down to the Second Narrows, with the exception of a short section at the lower end, extends along a private right-of-way 66 feet in width, with extra land at the intakes and at the Second Narrows, all owned by the city.

The chief object of maintaining this as a private right-of-way, is to give the city absolute control over this system at all times, so that the necessary repairs can be made and new mains laid or any other work done without asking the consent of the Municipality of North Vancouver or incurring damages that would follow, should this pipe line right-of-way be converted into a public highway.

The Seymour Creek Valley is formed by steep hill-sides on each side of the creek, one or two of them being liable to slides at times. In locating the pipe line it was thought advisable to keep down as close as possible to the toe of the banks in the more solid ground, to secure the best safety to the pipes, and subsequent experience has proved this to be the only proper location.

The protection work done since the installation of the Capilano and Seymour Creek supply mains, has been chiefly timber, rock-filled cribbing placed along the banks of these creeks to prevent encroachment, due to the alteration from time to time of their channels.

RENEWAL AND REPAIR WORK TO SUBMERGED MAINS

Since the waterworks system was first installed, the chief repair work and renewals to the pipe system has been done at the crossing of the First Narrows. There have been four old submerged mains hauled out during the past 24 years, making a total of ten which have been installed during this period. There have been numerous repairs and about twelve bad breaks during this time, which have been repaired under water by divers. These breaks were caused chiefly by ships' keels landing on the pipes near the shore ends during foggy weather, or when these vessels were out of control.

MANAGEMENT

The Water Works Department is controlled by the Water Committee of the City Council and its management is under the direct supervision of the City Engineer with the Water Works Superintendent in charge of general [redacted] maintenance. The accounting is under the supervision of the City Comptroller, and all money required for extensions is borrowed by the issue of city debentures.

The receipts from water rates are used to pay the interest and sinking fund of the debentures, together with the operating expenses, the surplus passing into the general revenue of the city.

ENGINEERING

Since the year 1905, by a special arrangement with the City Council, the designing and engineering of the water works extensions, and supervision of construction, excepting the distributi[illegible] system and maintenance, has been performed by the writer, who is paid on a percentage basis.